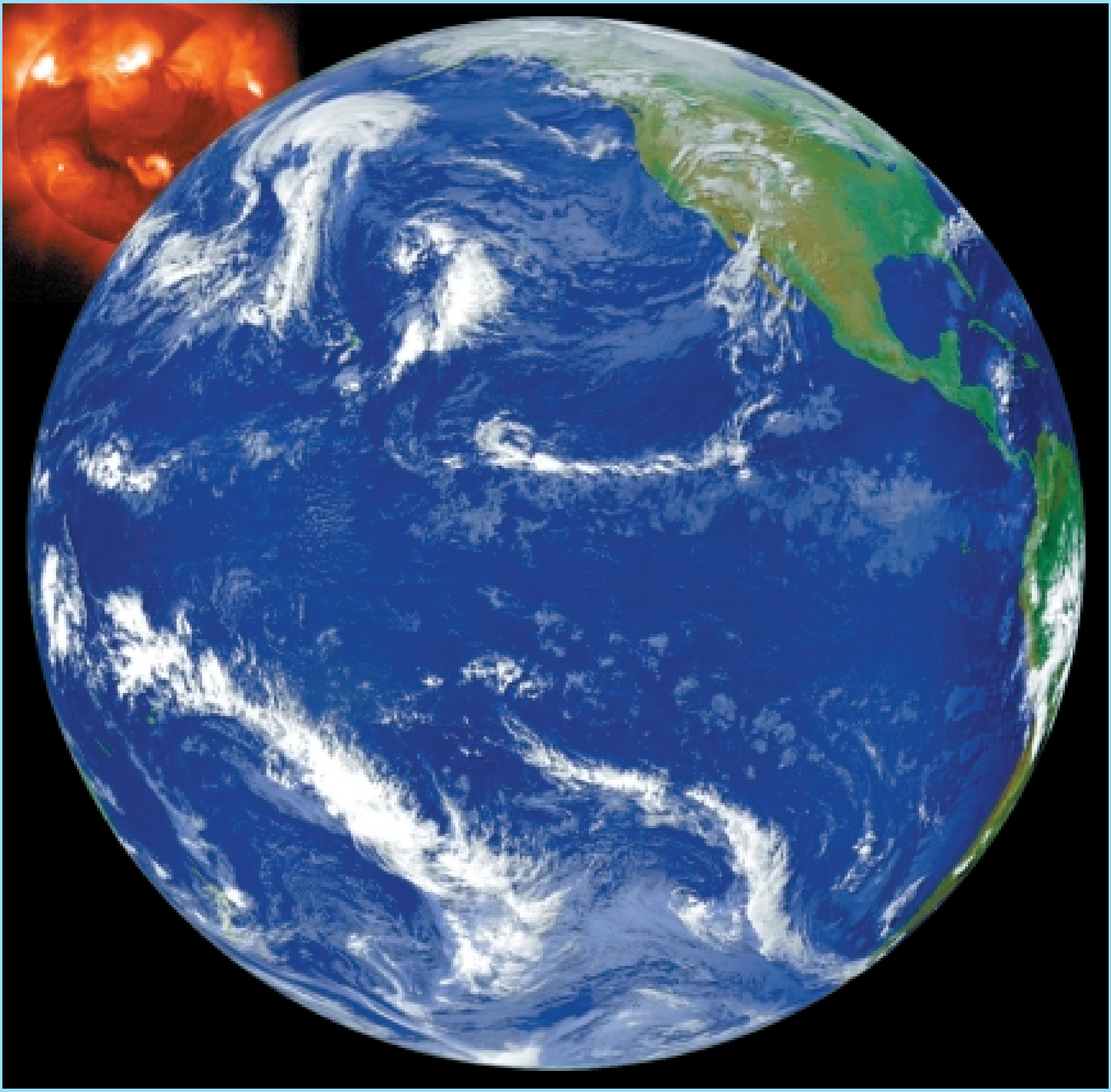
GOES NO/P/Q - The Next Generation



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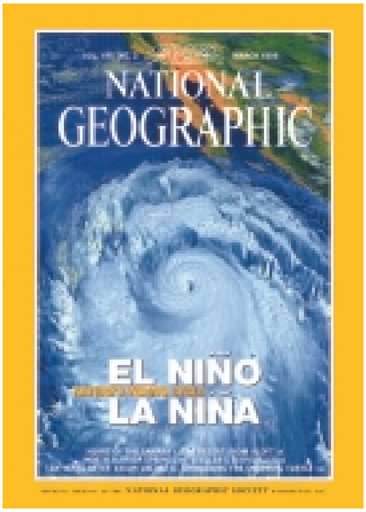
The impressive imagery of cloud cover produced by the Geostationary Operational Environmental Satellites (GOES) series, as viewed from orbit high above the Earth, has become a highlight and staple of television weather forecasts. Forecasting the approach of severe storms for more than 25 years, GOES has remained an essential cornerstone of weather observations and forecasting.



The GOES system of weather satellites provides timely environmental information to meteorologists and their audiences alike—graphically displaying the intensity, path, and size of storms. With El Niño and La Niña affecting people worldwide, GOES images have been featured on the covers of the international press, appearing in *National Geographic*, *Der Spiegel*, and *Life* magazines. GOES images have become so common that many people equate the appearance of hurricanes with the popularized images of Hurricanes Hugo, Andrew, and Floyd.

The GOES program is a joint development effort of the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) that began in 1974. NASA provides launch support and designs, engineers, and procures the satellites. After a satellite is launched and checked out by NASA, it is turned over to NOAA for its operations, which also determines the need for satellite replacement.

GOES spacecraft operate as a two-satellite constellation in geosynchronous orbit above the equator to observe 60 percent of the Earth. They measure the Earth's atmosphere, its surface, cloud cover, and the solar and geosynchronous space environment and provide a platform for the Imager, Sounder, Solar X-Ray Imager (SXI), and space environment monitoring instruments. The system also supports land- and ocean-based Data Collection Platforms (DCPs), transmits Weather Facsimile (WEFAX)/Low Rate Information Transmission (LRIT) and imaging and sounding data between Earth terminals, relays Emergency Managers Weather Information Network (EMWIN) broadcasts, and participates in the international Cospas-Search and Rescue Satellite-Aided Tracking (SARSAT) system.

NOAA and NASA are developing a new series of geosynchronous satellites that will continue and enhance the current five-satellite GOES I/M series. The new four-satellite series, designated GOES NO/P/Q, has changed its LRIT data transmission from an analog to a digital format that adds new capabilities to the space environment monitoring instruments and added the new EMWIN data channels.

Cospas is an acronym for the Russian words *Cosmicheskaya Sistyema Poiska Avariynich Sudov*, which mean "Space System for the Search of Vessels in Distress."

The launch of the prototype Synchronous Meteorological Satellite, *SMS-A,* in May 1974 inaugurated the series of geosynchronous satellites that has provided systematic, continuous observations of weather patterns. A second prototype, *SMS-B,* followed in February 1975. The GOES program formally began with the launch of the first operational spacecraft, *SMS-C/GOES-A*, in 1975, which was renamed *GOES 1* when it reached orbit. *GOES 2* and *GOES 3* followed in 1977 and 1978, respectively. These spacecraft obtained both day and night data on the Earth's weather from the Visible/Infrared Spin Scan Radiometer (VISSR), a scanning instrument that formed images of the Earth's surface and cloud cover for transmission to regional data-user stations for use in weather prediction and forecasting and also for monitoring the space environment.

"Geosynchronous" satellites orbit the Earth from west to east at an altitude of approximately 22,400 miles or 35,800 km and at a speed that keeps them fixed over the Earth's equator, making one rotation in 24 hours.

A radiometer is an instrument that measures electromagnetic radiation or energy.

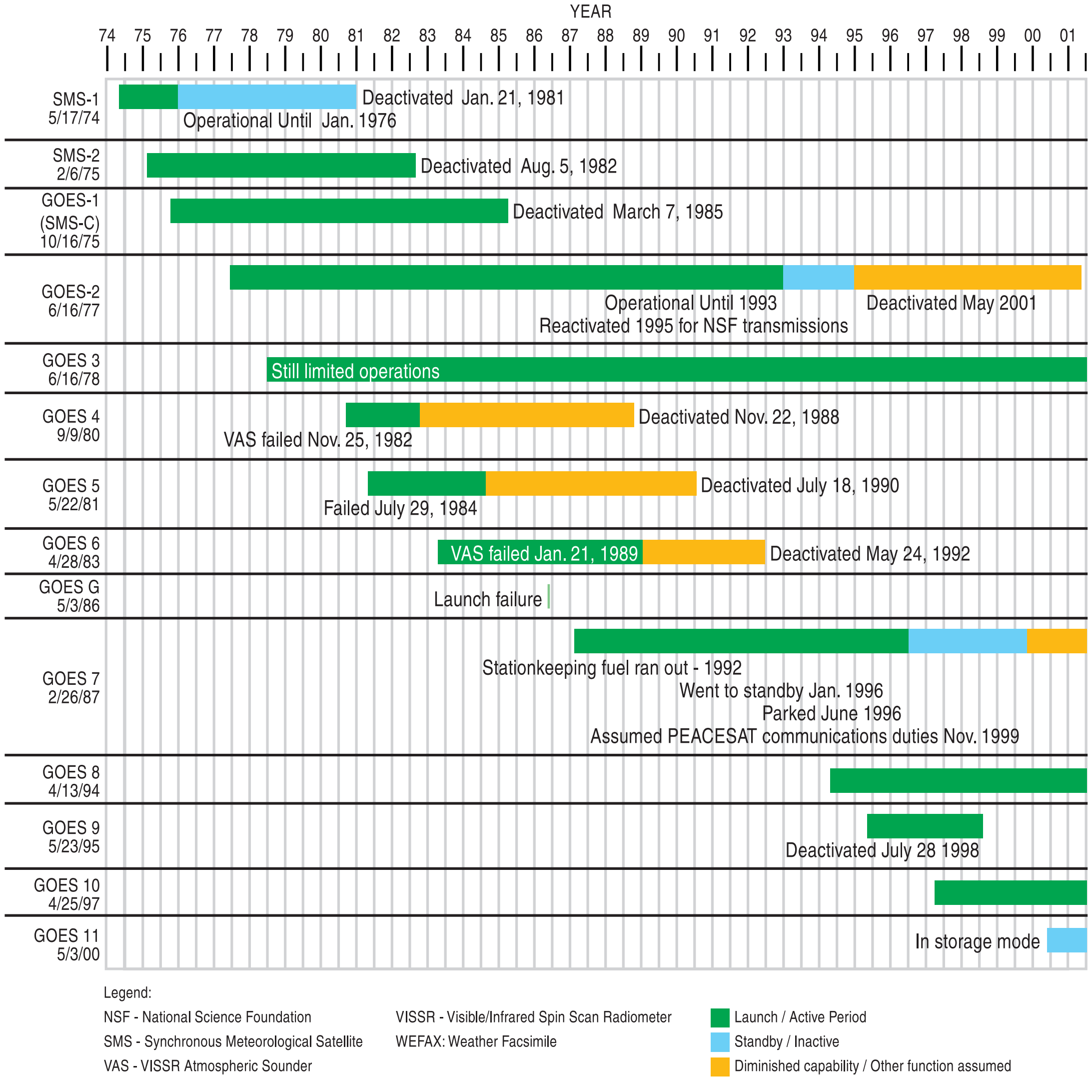
GOES 4-7 were similarly configured. *GOES 4,* launched in 1980, introduced an improved VISSR, the VISSR Atmospheric Sounder (VAS), which gathered the standard VISSR image data and also sounded the atmosphere, enabling meteorologists to acquire temperature and moisture data profiles. From these profiles, scientists could determine the altitudes and temperatures of clouds and draw a three-dimensional picture of their distribution in the atmosphere, leading to more accurate weather predictions. Using GOES imagery, meteorologists also measured the movement of clouds at different altitudes and determined their wind direction and speed to better understand atmospheric circulation patterns. A limitation of the VAS was that it could not gather imaging and sounding data simultaneously but had to alternate between the two functions.

GOES 7, launched in 1987, inaugurated the use of geosynchronous satellites for international search and rescue efforts. The spacecraft could receive signals from emergency transmitters on ships and planes in distress and send them to ground stations that coordinated search and rescue efforts.

"Real-time" is a common term which means that data is collected and relayed to the ground as soon as it occurs.

GOES 8-11 three-axis-stabilized satellites provided significant improvements. *GOES 8,* launched in 1994, carried separate and independently operating Imager and Sounder instruments. Now researchers could gather both imaging and sounding data continuously without having to alternate between the two operating modes. Image resolution also improved significantly, and the GOES search and rescue system also became operational.

The GOES system has continued to improve with new technological innovations and sensors. The present-day GOES spacecraft help meteorologists observe and predict local weather



events, including thunderstorms, tornadoes, flash floods, and even snow squalls. GOES observations have proven helpful in monitoring dust storms, volcanic eruptions, and forest fires. Currently, the system consists of *GOES 8*, operating as *GOES-East* in the eastern part of the constellation at 75° west longitude, and *GOES 10*, operating as *GOES-West* at 135° west longitude. *GOES 11* is in standby mode and is serving as a spare that backs up both satellites. *GOES 12* (GOES M) is scheduled for launch in mid-2001. See "Prior Spacecraft" beginning on page 29 for more detailed information about each spacecraft.

Overall, the program continues to provide environmental data for routine meteorological analyses and forecasts, serve user agencies, and provide environmental data that helps expand knowledge of storm development and forecast severe weather events. It supports the Cospas-Sarsat system, contributes to the development of worldwide on-site environmental warning services and enhancements of basic environmental services, improves the capability for forecasting and providing real-time warning of solar disturbances, and provides data that may be used to extend knowledge and understanding of the atmosphere and its processes.

The GOES NO/P/Q spacecraft, built by Boeing Satellite Systems, Inc., (formerly Hughes Space and Communications) is based on the Boeing 601 spacecraft and is the latest in the series of three-axis body stabilized geosynchronous weather satellites. The new satellites will accurately locate severe storms and other weather phenomena, resulting in precise warnings to the public. The spacecraft enable the primary sensors to “stare” at the Earth and thus frequently image clouds, monitor the Earth’s surface temperature, and sound the Earth’s atmosphere for its vertical temperature and water vapor distribution. Atmospheric phenomena can be tracked, ensuring real-time coverage of events such as severe local storms, tropical

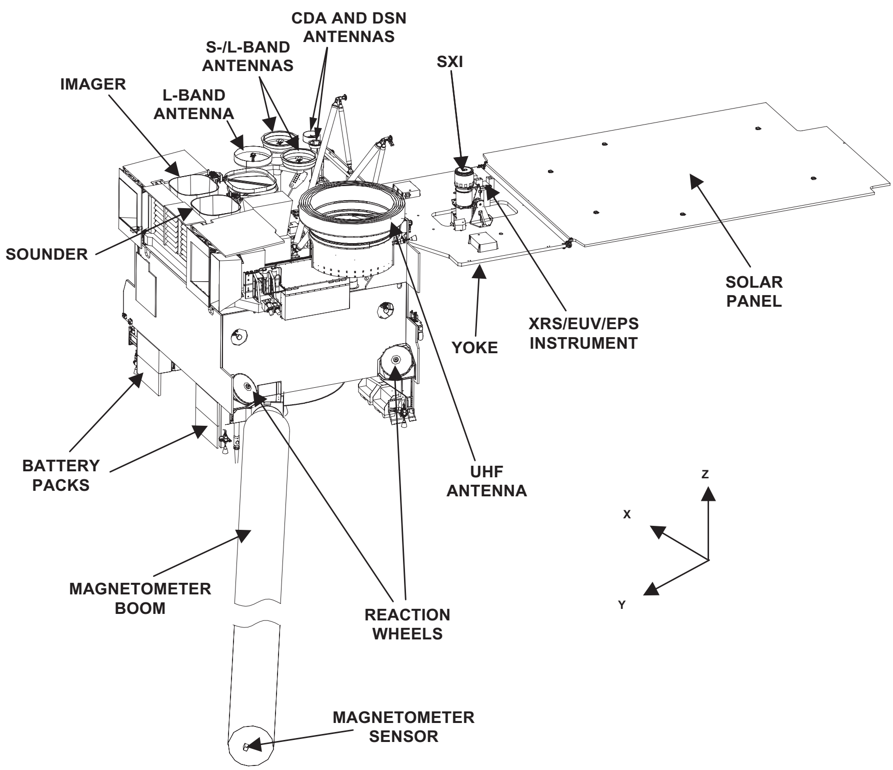
Spacecraft Specifications

Dimensions	Stowed:	97 in. x 180 in. x 113 in. (2.56 m x 4.6 m x 2.9 m)
	In orbit:	331 in. x 358 in. x 113 in. (8.4 m x 9.1 m x 2.9 m)
		Magnetometer to body: 335 in. (8.5 m)
	Solar array:	26 ft. 8 in. (8.2 m)
		Yoke panel: 7 ft. 9 in. x 6 ft. 0.1 in. (231.1 cm x 183.2 cm)
Mass	At launch:	7,075.7 lb. (3,209.5 kg) (including fuel)
	Dry mass:	3,402 lb. (1,543 kg)
Power	Beginning of life:	2.22 kW at summer solstice, 2.47 kW at equinox
	End of life:	2.07 kW at summer solstice, 2.25 kW at equinox
	Batteries:	3 NiH_2 packs (8 cells per pack)
Lifetime	Five years operations plus two years of on-orbit storage. Five years of ground storage is also possible.	

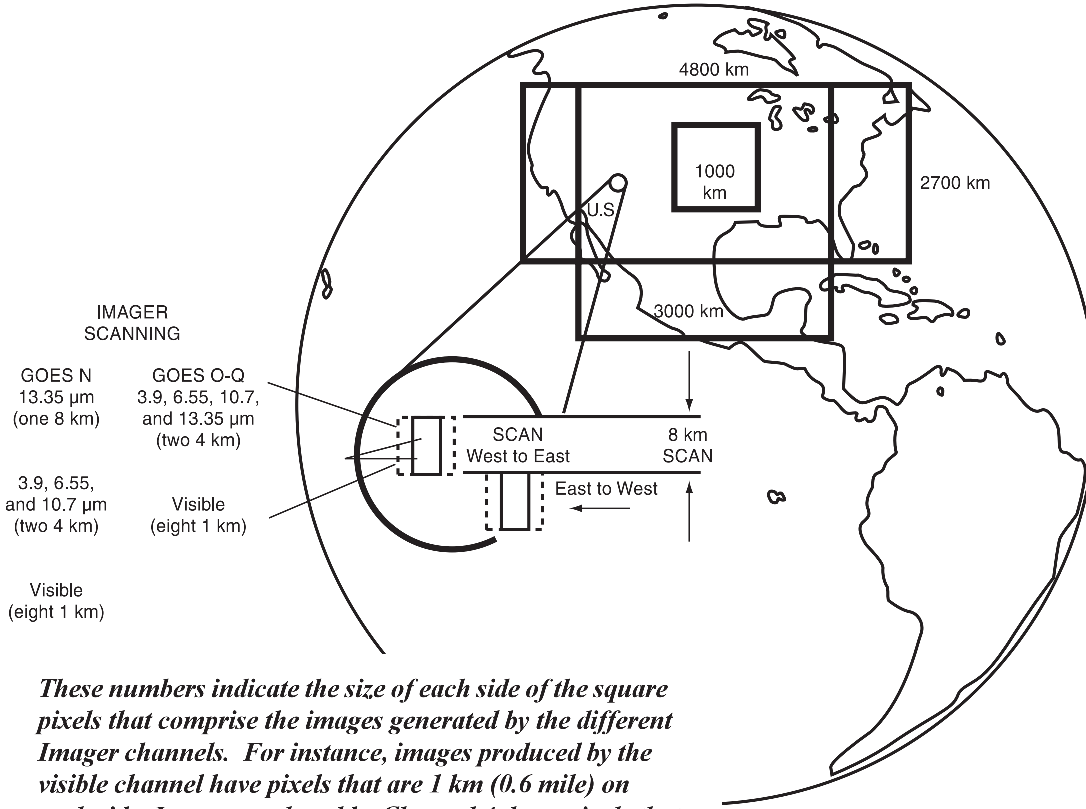
hurricanes, and cyclones—meteorological events that directly affect public safety, property, and ultimately, economic health and development.

The GOES NO/P/Q spacecraft carry an Imager, Sounder, and collection of other space environment monitoring instruments. The Solar X-Ray Imager (SXI) is part of the Space Environment Monitor (SEM) subsystem. In addition, the satellites carry a search and rescue transponder that detects alerts from individuals, aircraft, and maritime vessels in distress and then communicates these alerts to ground-based centers for transmission to rescue authorities.

Both the Imager and the Sounder have flexible scan control, which means that the instruments can scan small areas as well as all of North and South America and global scenes (full disk). Small area scan selection permits rapid and continuous viewing of local areas for monitoring of regional phenomena and accurate wind determination. The scan control also allows continuous observations of severe storms and changing, short-lived weather phenomena. Commands from the NOAA control center control the position and size of the area selected for observation.



On-board Instrumentation



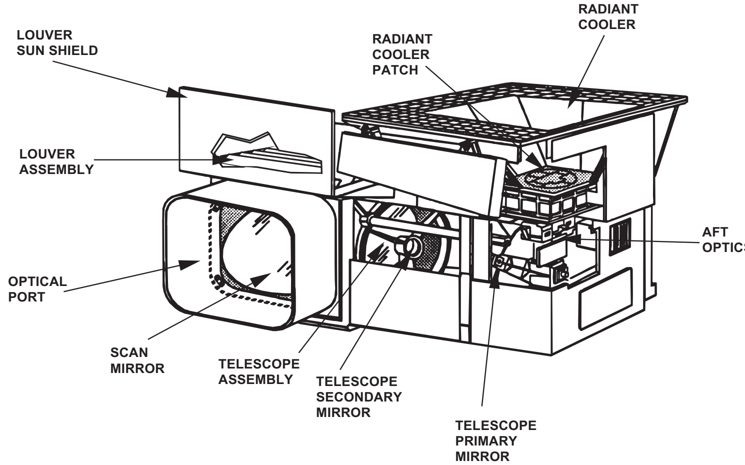
These numbers indicate the size of each side of the square pixels that comprise the images generated by the different Imager channels. For instance, images produced by the visible channel have pixels that are 1 km (0.6 mile) on each side. Images produced by Channel 4 have pixels that are 4 km (2.5 miles) on each side. A smaller number indicates better-quality images. Note that the channel resolution for channel 3 has changed for GOES O-Q.

GOES Area Scan

The resolution, or clarity, of each image depends upon the size of the picture elements (pixels) in the image that is being acquired. The size of each pixel depends on which band or channel is being used. Different channels take images with different-size pixels. For instance, an image taken with Channel 2 generates images whose pixels are 4 km (2.5 miles) on each side. That provides twice the resolution of an image whose pixels are 8 km (5 miles) on each side such as images generated by Channel 6. All Sounder channels generate data that have circular pixels with 10-km (6.2-mile) diameters.

Imager

The Imager, developed by ITT A/CD (ITT Aerospace/ Communications Division), Fort Wayne, Indiana, is an imaging radiometer that uses data obtained from its five channels to continuously produce images of the Earth's surface, oceans, severe storm development, cloud cover, cloud temperature and height, surface temperature, and water vapor. It allows users to identify fog at night, distinguish between water and ice clouds during daytime hours, detect hot spots such as volcanoes and forest fires, locate a hurricane eye at night when it is covered with thin clouds, and acquire measurements of nighttime ground and sea surface temperatures.



Imager

The Imager simultaneously senses emitted thermal and reflected solar energy from selected areas of the Earth. It uses a scan mirror system to alternately sweep east to west and west to east perpendicular to a north-to-south path. The rate of scanning allows the instrument to gather data in its five spectral channels from a 1,864 x 1,864-mile area (3,000 x 3,000 km) in three minutes and from an area of 621 x 621 miles (1,000 x 1,000 km) in just 41 seconds.

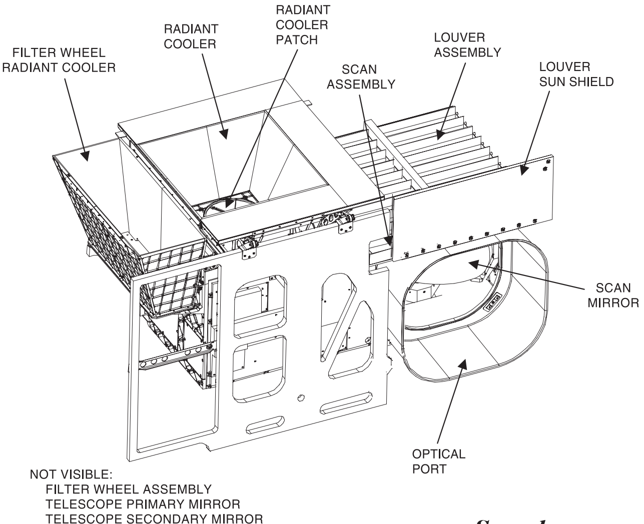
Imager Channel Products

Channel	Wavelength (μm)	Products
1	visible - 0.52 - 0.71	Daytime cloud cover
2	3.73 - 4.07	Nighttime cloud cover
3	5.80 - 7.30	Water vapor
4	10.20 - 11.20	Earth and cloud images; sea surface temperature and water vapor
5*	Not on GOES NO/P/Q	Not applicable
6	13.00 - 13.70	Cloud cover and cloud height

*Channel assignment 5 is reserved for GOES I/M data products in the wavelength band between 11.50 - 12.50 mm

Sounder

The Sounder, also built by ITT A/CD, provides meteorologists with a detailed description of conditions in the atmosphere at any time. It gathers data over an approximately circular area extending from 60° north latitude to 60° south, allowing meteorologists to deduce atmospheric temperature and moisture profiles, surface and cloud-top temperatures, and ozone distributions by mathematical analysis and by adding to data from the Imager. Sounder data is also used in computer models that produce mid- and long-range weather forecasts.



Sounder

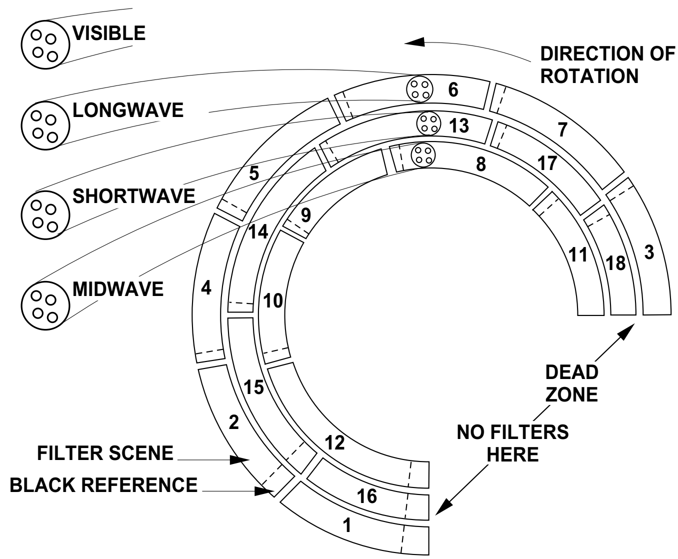
Detecting conditions that may lead to severe storms is one major function of the Sounder. Data collected by the instrument is processed on the ground so that it generates a numerical designation called a "lifted index," which is an indicator of atmospheric stability and of how much air near the surface would keep rising if it were lifted to the middle of the atmosphere. The less stable the atmosphere, the greater the likelihood of severe storms.

The Sounder probes the atmosphere measuring emitted radiation in one

Sounder Channel Allocation and Purpose

Detector	Channel Number	Central Wavelength (μm)	Purpose
Longwave	1	14.71	Temperature sounding
	2	14.37	Temperature sounding
	3	14.06	Temperature sounding
	4	13.64	Temperature sounding
	5	13.37	Temperature sounding
	6	12.66	Temperature sounding
	7	12.02	Surface temperature
Midwave	8	11.03	Surface temperature
	9	9.71	Total ozone
	10	7.43	Water vapor
	11	7.02	Water vapor
	12	6.51	Water vapor
Shortwave	13	4.57	Temperature sounding
	14	4.52	Temperature sounding
	15	4.45	Temperature sounding
	16	4.13	Temperature sounding
	17	3.98	Surface temperature
	18	3.74	Surface temperature
Visible	19	0.70	Clouds

visible band and 18 thermal bands that are sensitive to temperature, moisture, and ozone as well as to reflected solar radiation. It measures radiated energy at different depths (altitudes) and also records surface and cloud-top temperatures and ozone distribution. It looks at conditions in "columns" of the atmosphere—cylindrical sections that extend from the Earth's surface to the upper reaches of the atmosphere.



Sounder Filter Wheel Assembly

The Sounder operates by means of a scan mirror that steps across the disk of the Earth in a west to east and east to west direction along a north-to-south path as the filter wheel rotates.

The filter wheel has 18 filters, each of which corresponds to a particular band or wavelength in the spectrum. Each filter allows only energy with a particular wavelength to reach the sensors. All 18 filters and the visible band are sampled during each rotation, which occurs 10 times per second.

One-fourth of the wheel has no filters, which allows time for the scanner to move, or "step," to a new scan position during the period of rotation. For the visible band, the reflected solar energy bypasses the filter wheel completely and goes directly to the nineteenth visible channel detector. The Sounder's detector array assemblies sample four separate fields or atmospheric columns simultaneously.

The Sounder operates independently of and simultaneously with the Imager, using a similar type of flexible scan system. The Sounder scans the full Earth and can be commanded to scan and provide soundings of local regions of interest. It can provide full-Earth imagery, sector imagery, and scans of local regions. Sounder data from the chosen scan area is fed into powerful computer programs that develop advanced numerical weather prediction models for use by weather forecasters.

Space Environment Monitor

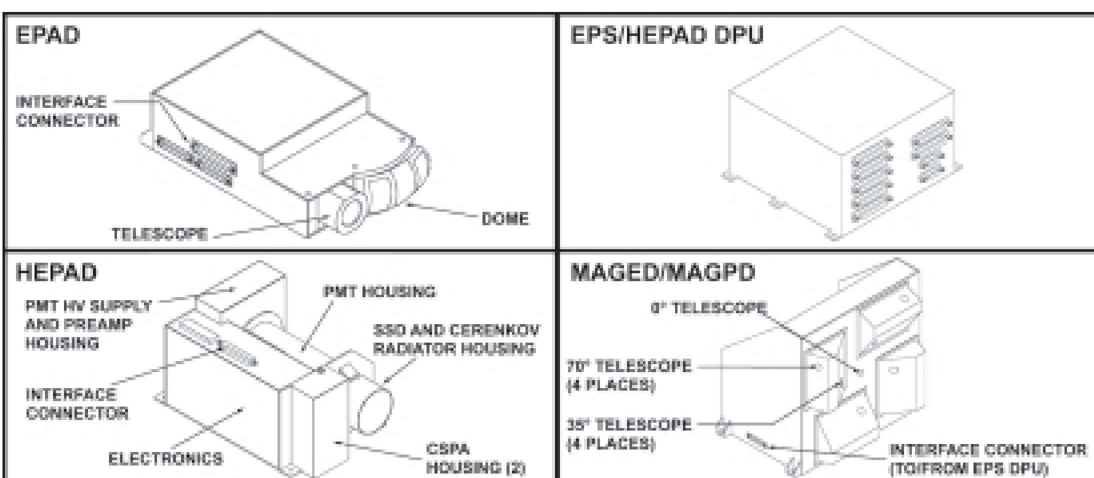
The SEM consists of three instrument groups: 1) two magnetometer sensors, 2) a solar x-ray sensor (XRS) and extreme ultraviolet (EUV) sensor, and 3) an energetic particle sensor (EPS) package. The SXI is also part of the SEM.

Operating at all times, the SEM provides real-time data to the Space Environment Center (SEC) in Boulder, Colorado. The SEC, as the nation's "space weather" center, receives, monitors, and interprets a wide variety of solar terrestrial data and issues reports, alerts, warnings, and forecasts for special events such as solar flares or geomagnetic storms (see http://www.sec.noaa.gov). This information is important for military and civilian radio communication, satellite communication and navigation systems, electric power networks, geophysical exploration, Shuttle and Space Station astronauts, high-altitude aviators, and scientific researchers.

Energetic Particle Sensor

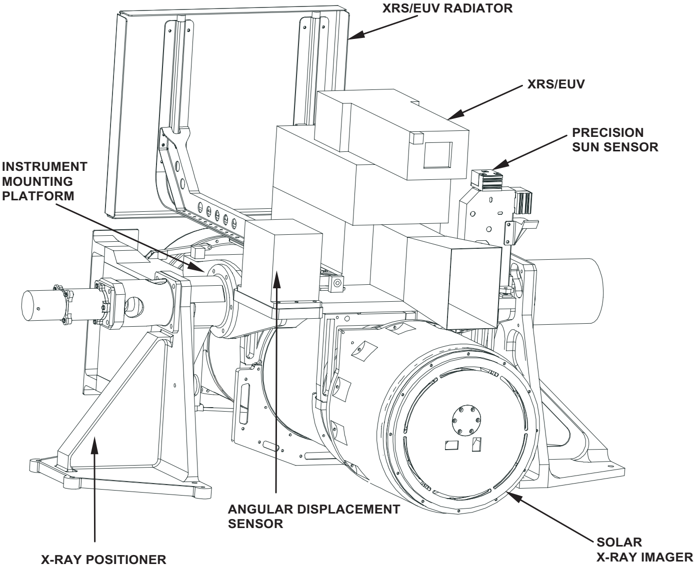
The EPS, developed by Panametrics, Inc., measures the energetic particles at geosynchronous orbit, including protons, electrons, and alpha particles. The radiation in the environment consists of particles trapped within the Earth's magnetosphere as well as energetic particles arriving directly from the sun and cosmic rays that have been accelerated deep in space.

The sensors accurately measure the number of particles so that hazardous levels can be detected and the risk to satellites and astronauts can be determined. They also accurately measure the particles with lower energy to assess the likelihood that the spacecraft's surface will develop an electrostatic charge.



Elements of the EPS: the EPAD, EPS/HEPAD DPU, HEPAD and MAGED/MAGPD

The continuous long-term monitoring of the environment provided by these sensors forms the basis for engineering guidelines for satellite design, for the analysis of satellite failure and anomalous behavior, for assessing the risk of human exposure to radiation, and for research leading to improved models of the radiation environment. The sensors on the EPS have been expanded on GOES NO/P/Q to provide coverage over an extended energy range and with improved directional accuracy.

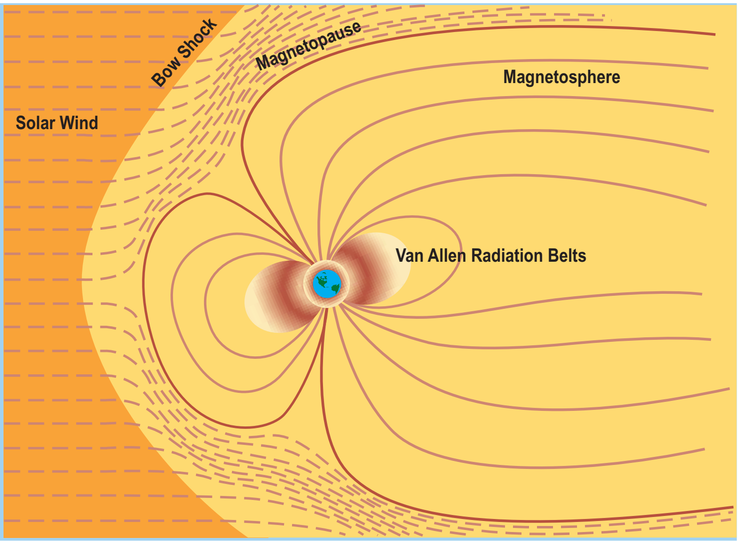


GOES Sun-Observing Package

Magnetometers

The GOES NO/P/Q satellites have two identical magnetometers, provided by Science Applications International Corporation (SAIC), Inc. They both check the magnitude and direction of the Earth's geomagnetic field, detect variations in the magnetic field near the spacecraft, provide alerts of solar wind shocks or sudden impulses that impact the magnetosphere, and assess the level of geomagnetic activity. Magnetometer data is archived for the scientific community and other interested users. One magnetometer is mounted on the end of the boom 27.9 feet (8.5 m) from the spacecraft.

The magnetosphere is the comet-shaped region around the Earth that is affected by the Earth´s magnetic field. It extends some 37,282 miles (60,000 km) from the Earth on the side facing the sun, but on the opposite side, it extends much farther. The boundary of the magnetosphere is called the "magnetopause." Read about the magnetosphere at http://www-spof.gsfc.nasa.gov/Education/.



The other is positioned on the same boom 2.6 feet (0.8 m) closer to the spacecraft. The second serves as a backup in case the first magnetometer fails.

X-Ray Sensor and Extreme Ultraviolet Sensor

The XRS is an x-ray telescope that observes and measures solar-x-ray emissions in two ranges—one from 0.05 to 0.3 nanometers (nm) and the second from 0.1 to 0.8 nm. In real-time, it measures the intensity and duration of solar flares in order to provide alerts and warnings of potential geophysical responses such as changes in ionospheric conditions that can disrupt radio communications and Global Positioning System (GPS) signals. XRS data is also used to estimate solar flare parameters such as rise-time (how quickly a flare grows) and the length and temperature of a flare for use in energetic proton predictions.

The five-channel EUV telescope is new on the GOES NO/P/Q series. It measures solar extreme ultraviolet energy in five wavelength bands from 10 nm to 126 nm. The EUV sensor provides a direct measure of the solar energy that heats the upper atmosphere and creates the ionosphere. Changes in solar EUV output can change the density of the upper atmosphere by a factor of 10, which will cause increased drag for satellites in low-Earth-orbit. Similarly, these changes in EUV level can increase the density of the ionosphere by a factor of 10, which will affect radio communications and satellite navigation.

Both the XRS and EUV are provided by Panametrics, Inc., and are part of the sun-observing package mounted on the yoke of the solar panels. The entire package (including the SXI) continually points at the sun by using a Precision Sun Sensor (PSS) to control the solar panels to track the sun in azimuth and the x-ray positioner (XRP) to track the sun in elevation.

Solar X-Ray Imager

The SXI, developed by Lockheed-Martin Advanced Technology Center (LMATC), uses a telescope assembly to observe the sun's x-ray emissions and provide early detection and location of flares. These observations allow space weather forecasters to monitor solar features and activities such as solar flares, loops, coronal holes, and coronal mass ejections from the

Space Environment Monitoring Terminology

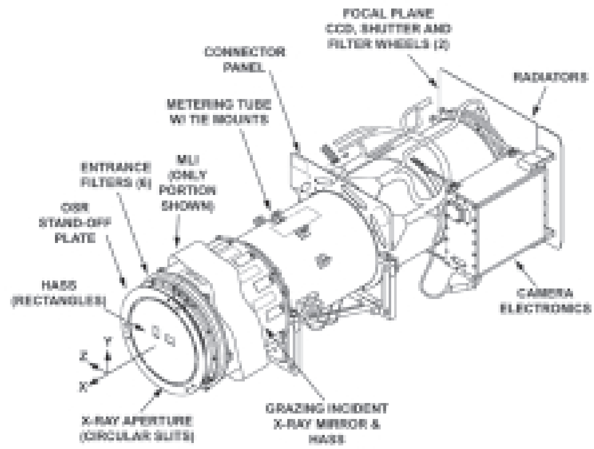
Cosmic rays - A rain of fast ions that constantly bombards the Earth, coming from distant space and much more energetic than any found in the magnetosphere.

Magnetometer - An instrument that measures the magnitude and direction of the Earth's magnetic field at geostationary orbit.

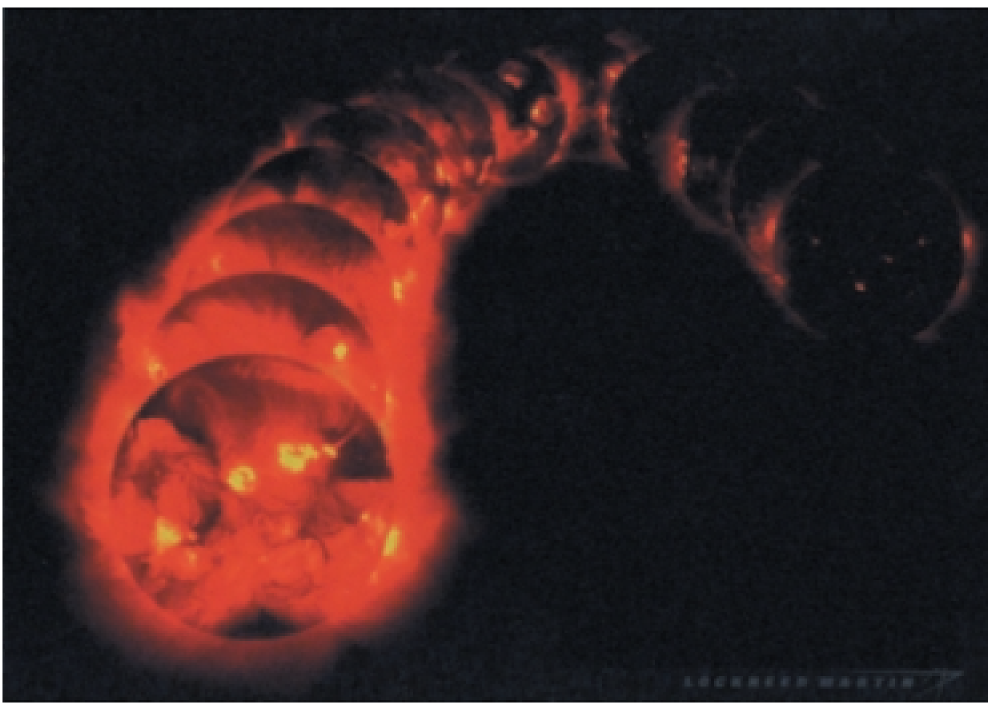
Ionosphere - A region of the upper atmosphere that extends from about 30 miles (50 km) to 250 miles (400 km) above the Earth's surface. It is characterized by the presence of ions and electrons that affect radio communications and satellite navigation.

sun. Knowledge of the location and size of these activities greatly improves the forecaster's ability to predict which solar phenomena may affect the Earth and its atmosphere and when to issue forecasts and alerts of "solar weather" conditions that may interfere with ground and space systems.

"Solar weather" can have quite far-reaching effects. NOAA categorizes these as radio blackouts, radiation storms, and geomagnetic storms. Radio blackouts interfere with military and commercial communications and navi-



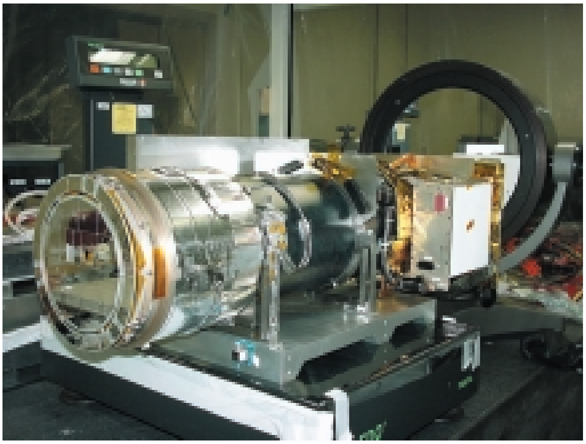
SXI Telescope Assembly



The 12 x-ray images of the sun's atmosphere, obtained between 1991 and 1995 at 120-day increments, illustrate how the corona changes during the waning part of the solar cycle. Only the sun's atmosphere is hot enough to emit x-rays; the sun's surface is not as hot and shows up as a black disk on this image. Images were taken by the Japanese Yohkoh satellite's Soft X-ray Telescope, which is similar to the SXI. (Images courtesy of Lockheed Martin)

gation systems. Radiation storms can damage operating spacecraft and expose humans to excessive radiation during high-altitude missions. Geomagnetic storms damage power utility systems and disrupt communications and navigation systems.

NOAA and U.S. Air Force forecasters will use data and images from the SXI to monitor solar conditions that affect space weather conditions, including the dynamic environment of energetic particles, solar wind streams, and coronal mass ejections emanating from the sun.



Solar X-Ray Imager

The SXI captures full-disk images of the sun in the x-ray spectral band from 0.6 to 6.0 nm. It is commanded from the ground and can capture at least one image per minute. Ground command can reconfigure the SXI to take image sequences with varying exposure times in different parts of the x-ray spectral band, depending on the level of solar activity. If enabled by ground command, the instrument can also automatically change its imaging sequences during very high solar activity.

The telescope consists of entrance filters that block radiation outside the 0.6 to 6.0-nm range. The x-ray mirror and High Accuracy Sun Sensor (HASS) focus the image on the camera, and the HASS keeps the instrument focused on the sun in the east-west direction. Additional filters set farther back in the telescope allow selection of particular wavelengths in the 0.6 to 6.0-nm range and also protect the Charge Coupled Device (CCD) from undesired radiation.

Images are captured in digital form on the CCD. From there, they are transmitted directly to NOAA's SEC, which processes the data in real time for its own use and use by others in predicting space weather. In processing the data, the SEC corrects known image defects and calibrates and stores each image. The calibrated images are used to automatically locate solar flares, produce movie sequences, calculate coronal hole indices, display on real-time monitors, and produce products for the general public. The user will be able to view PNG and MPEG files and order high-resolution images for research. Data will be archived at the NOAA National Geophysical Data Center (NGDC) at http://www.ngdc.noaa.gov.

Instrument of Opportunity

The GOES NO/P/Q spacecraft are designed so they can accommodate an additional observational instrument. This instrument of opportunity would be provided by universities, research institutions, or other organizations that have expressed an interest, can finance the costs associated with the opportunity, and can meet the instrument accommodation requirements.

At present, no instruments of opportunity have been identified for inclusion on any of the GOES spacecraft in the NO/P/Q series.

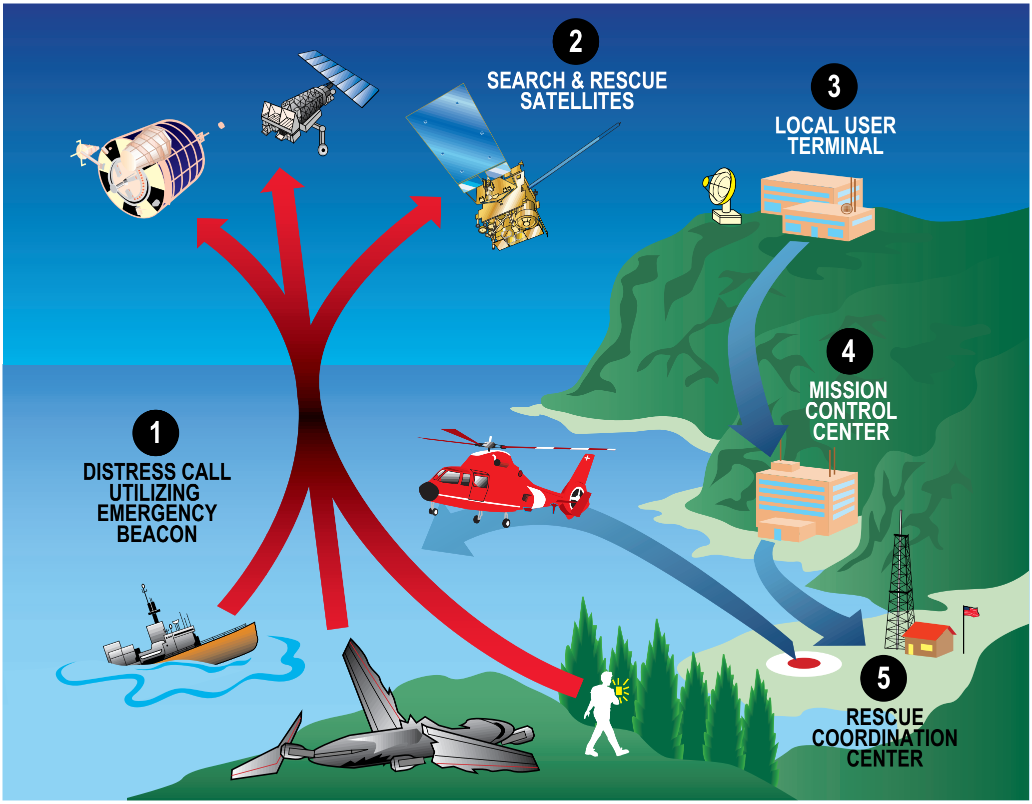
Cospas-Sarsat System

The GOES system, developed by NASA, participates in the international Cospas-Sarsat system that has helped save thousands of individuals since its inception in 1982. GOES spacecraft detect signals transmitted by 406-MHz emergency beacons carried by aircraft (Emergency Locator Transmitters—ELTs), maritime vessels (Emergency Position Indicating Radio Beacons—EPIRBs) and individuals (Personal Locator Beacons—PLBs). Optional GPS-equipped beacons will allow GOES spacecraft to precisely locate distress signals and significantly improve the response time for providing rescue assistance.

When the transponder on the spacecraft detects an alert, it transmits the alert from the spacecraft to a Local User Terminal (LUT) located within the field of view of the spacecraft. The present U.S. LUTs for low-Earth-orbiting satellites are located at Fairbanks, Alaska; Vandenberg Air Force Base, California; Wahiawa, Hawaii; Johnson Space Center, Houston, Texas; NOAA, Suitland, Maryland; Anderson Air Force Base, Guam; and Sabana Seca, Puerto Rico. GOES 406-MHz reception is handled by Canada, and geosynchronous LUTs will soon be installed at Suitland, Maryland. When the LUT receives the SAR data from the satellite, it determines the distress location and forwards the data to the U.S. Mission Control Center (USMCC) at Suitland, Maryland. The signals sent by the GOES spacecraft can be used in conjunction with the signals sent by the polar-orbiting satellites in low-Earth-orbit to determine the location of the distress call.

When the location of the distress is determined, the MCC identifies the appropriate Rescue Coordination Center (RCC) and forwards the distress data after removing redundant information. LUTs and MCCs are also located in Canada, France, Russia, and 10 other cooperating countries. All MCCs cooperate in forwarding data to provide rapid global delivery of distress locations received through the satellites.

The U.S. portion of the Cospas-Sarsat system is operated by the NOAA SARSAT Office in Suitland, Maryland. Additional information on the system including the latest U.S. and worldwide lives saved can be obtained at http://www.sarsat.noaa.gov.



Cospas-Sarsat System

1. Emergency beacons are activated in situations of "grave and imminent danger" when lives are at risk.

2. Emergency alerts received by the satellites are retransmitted to 38 automatic (unstaffed) ground stations worldwide. These stations are called Local User Terminals (LUTs).

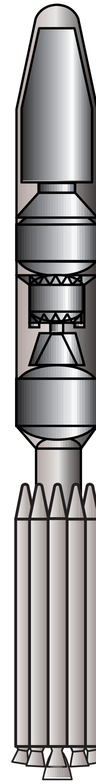
3. Messages are routed to a Mission Control Center (MCC) in the country that operates the LUT. Routed messages include beacon location computed at the LUT if the message was received by one of the system's low-Earth-orbiting satellites. Messages received by system satellites in geosynchronous orbit provide instantaneous alerting and can include location information if the beacon is a self-locating type.

4. After validation processing, alerts are relayed depending on beacon location or country of registration (406-MHz beacons only) to either another MCC or to the appropriate Rescue Coordination Center (RCC).

5. The U.S. Coast Guard and Air Force operate U.S. RCCs. The Air Force Rescue Coordination Center at Langley AFB, Virginia, coordinates all inland SAR activities in the lower 48 states. Usually, the actual search and rescue is carried out by the Civil Air Patrol or local rescue services. The Coast Guard coordinates and conducts most maritime SAR missions from RCCs located in nine Command Districts around the United States and two Rescue Sub-Centers (RSCs) in San Juan, Puerto Rico, and Guam. The Coast Guard also coordinates rescue missions in Hawaii.

   In Alaska, the Air Force operates an Alaskan Rescue Coordination Center in Anchorage at Ft. Richardson. Air National Guard units, the Alaska State Police, and local authorities carry out Alaskan SAR.

A Delta III space launch vehicle (SLV) will be used to launch the GOES N and GOES O. This SLV has evolved from the Delta II, which has been successfully used for more than 10 years. The Delta III, provided by Boeing, is a two-stage vehicle with a payload fairing, payload attach assembly, and avionics system. The Delta III can deliver a payload of 8,400 lbs. (3,810 kg) to geosynchronous transfer orbit.



The Delta III first stage is powered by a Boeing RS-27A main engine with two vernier engines used to control roll during main engine burn and also attitude between main engine cutoff (MECO) and first-stage separation. To enhance first-stage performance, the SLV uses nine 46-in. (1.17-m)-diameter Alliant Techsystems graphite-epoxy motors (GEMs), derived from those used on Delta II but which are larger and produce more thrust. Liquid oxygen (LO_2) is used as the propellant for this stage.

A Pratt & Whitney RL10B02 engine, which produces 24,750 lbs. (111,094 newtons) of thrust, powers the second stage. This engine, derived from the RL10 engine, has flown for more than 30 years. The second stage carries more propellant than the Delta II and burns cryogenic (cold) fuels, which produce more energy, allowing lift of heavier payloads.

Delta III Major Events

Event	Time From Ignition (sec.)
Ignition	0
Maximum dynamic pressure	42
Jettison ground lit solid motors	83
Jettison air lit solid motors	162
Jettison fairing	226
Main engine cutoff	260
Second stage ignition	281
Second stage cutoff 1	762
Second stage restart	1307
Second stage cutoff 2	1510
Spacecraft separation	2174

The Delta III uses a 13.1-ft. (4-m)-diameter fairing that separates into halves in flight to permit satellite deployment. The payload is placed into the fairing before it is transported to the launch pad and integrated with the launch vehicle.

GOES P and Q could be launched from Delta IV or Atlas III launch vehicles. The Atlas III is an improved version of the established Atlas II family of launch vehicles. The Atlas

Atlas III Launch Vehicle

consists of a booster section, a sustainer section, and an upper stage. It would be provided by Lockheed Martin Space Systems Company.

The GOES NO/P/Q satellites will be launched from Cape Canaveral Air Force Station, Florida. They will be launched into a geosynchronous orbit approximately 22,240 statute miles (35,790 km) above the equator with an inclination angle of plus or minus 0.5° to the equator.

The GOES launch and orbit insertion sequence starts before liftoff with a buildup of thrust following Stage I engine ignition. Then hold-down bolts are fired and the launch vehicle lifts off. After clearing the launch pad, the launch vehicle climbs to its desired flight altitude and begins to pitch over in the trajectory phase. The solid strap-on engines are jettisoned at approximately 162 seconds after liftoff. The payload fairing is jettisoned from the launch vehicle at approximately 226 seconds. The control logic then provides a signal that cuts off the main engine and 21 seconds later, ignites the second stage. The second stage is shut down (SECO) at 762 seconds and restarted at 1,307 seconds. Final second-stage cutoff occurs at 1,510 seconds.

The spacecraft separates from its upper stage 37 minutes (2,174 seconds) after liftoff. The SLV then injects the spacecraft into a highly elliptical supersynchronous transfer orbit to begin

Orbit Terminology

Apogee - The part of an orbit where the spacecraft or launch vehicle is the farthest from the Earth.

Geostationary orbit - An orbit in which the satellite is always in the same position in relation to the Earth. It is approximately 22,240 miles (35.790 km) above the Earth's equator.

Liquid apogee motor - A motor that fires at apogee and at perigee to circularize the orbit. This motor uses liquid fuel.

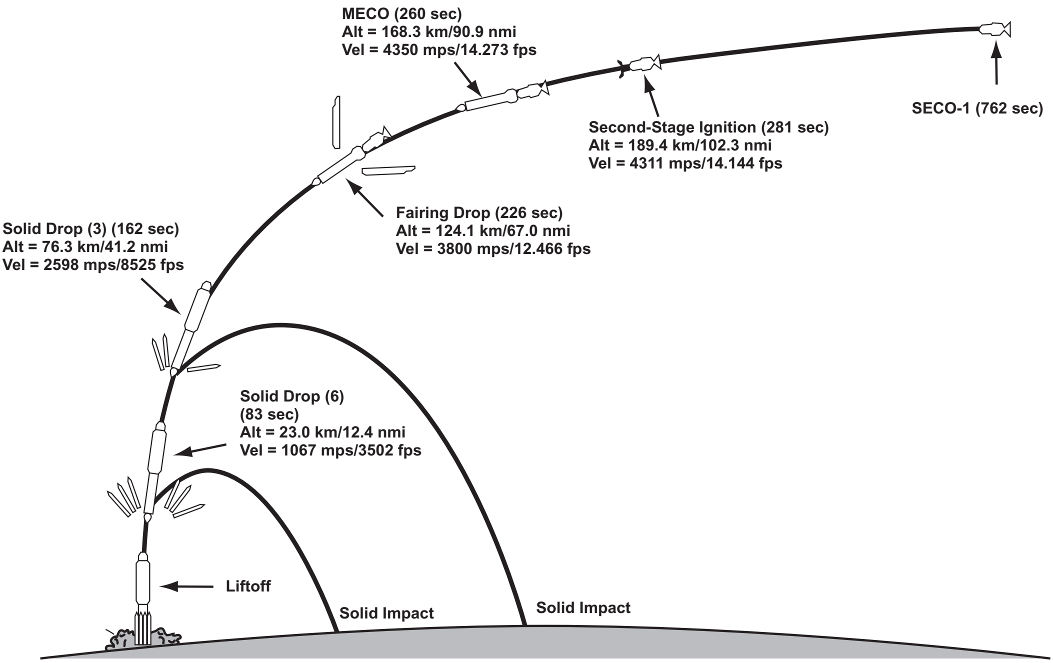
Perigee - The part of an orbit where the spacecraft or launch vehicle is closest to the Earth.

Supersynchronous transfer orbit - A temporary orbit that is farther away from the Earth than the final orbit.

Trajectory phase - The events that take place when the spacecraft is moving into its correct orbit.

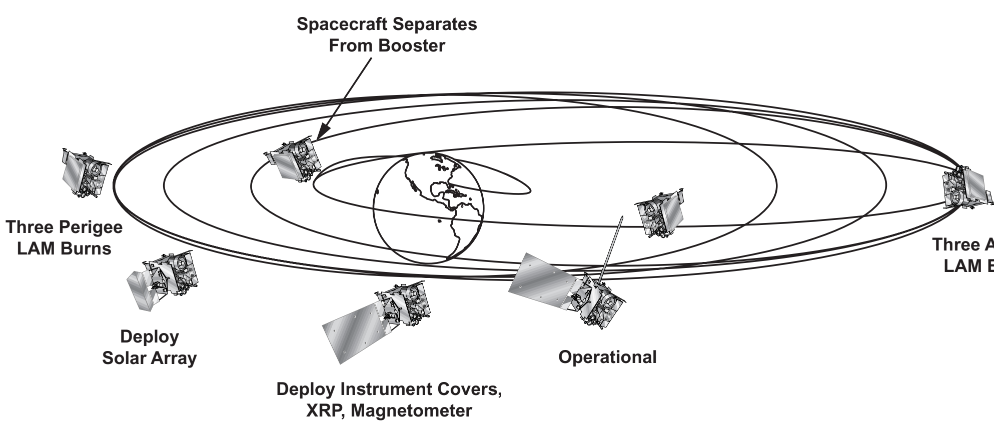
Transfer orbit - A temporary orbit that the spacecraft moves in before moving to its final position

Transfer orbit phase - The part of the orbit lasting from the time when the spacecraft separates from the launch vehicle to the last perigee motor firing (the motor firing that occurs when the spacecraft is at its perigee, i.e., closest to the Earth).



Typical Delta III Geosynchronous Transfer Orbit Sequence (Times Are Approximate)

the transfer orbit phase. A liquid apogee motor proceeds to place the spacecraft into the proper geostationary orbit through a sequence of several motor burns. The spacecraft arrives at its final location about 17 days after launch. During the test period that follows, thrusters are used to adjust the orbit.

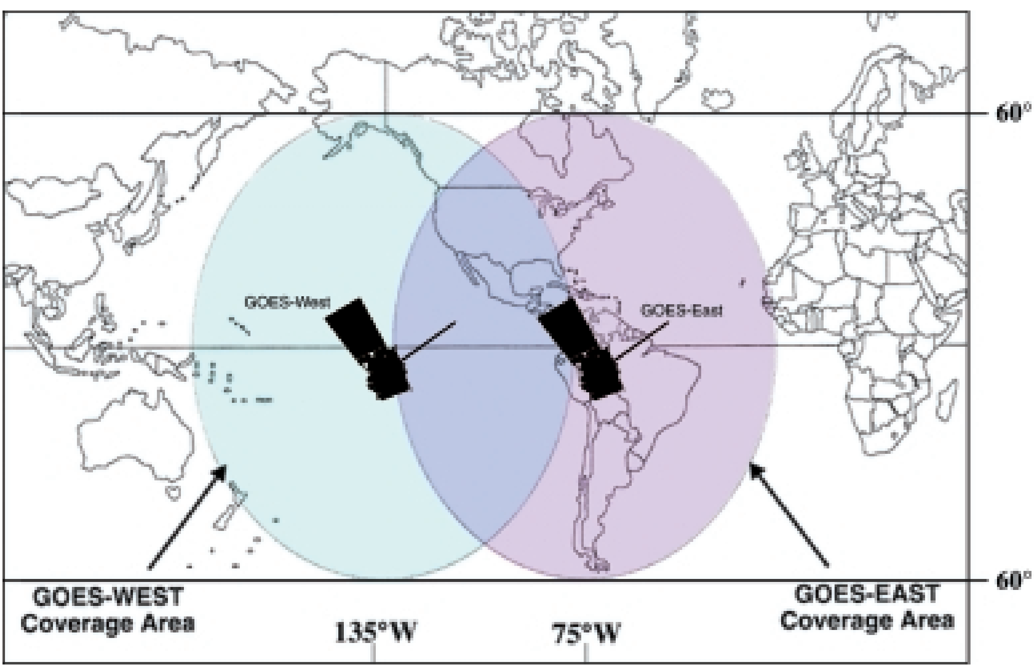


GOES Launch and Orbit Raising Mission Phases

During the launch sequence and transfer orbits, near-continuous coverage is provided by telemetry and control stations at Wallops, Virginia; Goldstone, California; Madrid, Spain; and Canberra, Australia.

Normally, two GOES spacecraft operate concurrently. *GOES-East* is stationed at 75° west longitude, and *GOES-West* is located at 135° west longitude, both over the equator. *GOES-East* observes North and South America and the Atlantic Ocean. *GOES-West* observes North America and the Pacific Ocean to the west of Hawaii. This area is commonly known to weather forecasters as "the birthplace of North American weather systems" because many weather systems that affect North America begin in this area. Together, these satellites provide coverage for the central and eastern Pacific Ocean, North, Central, and South America, and the central and western Atlantic Ocean. The images that are produced from this hemispheric coverage and which are familiar to many television viewers are called "full-disk images."

At least one GOES spacecraft is always within view of Earth-based terminals and ground stations within the western hemisphere. The Command and Data Acquisition station (CDAS) can see both spacecraft so that it can transmit commands and receive data from each satellite simultaneously. Data collection platforms (DCPs) within the coverage area of each spacecraft can transmit their surface-based sensed data to the CDAS by means of the onboard data col-



GOES Coverage Area

lection system (DCS). Ground terminals can also receive processed environmental data and EMWIN and WEFAX/LRIT transmissions.

Raw Imager and Sounder data received at the NOAA CDAS is processed in the spacecraft support ground system with other data to provide accurate, Earth-located, calibrated imagery and sounding data in near real time for uplink to the satellite and retransmission from the GOES spacecraft to primary end users, principally the seven National Weather Service field service stations located throughout the United States.

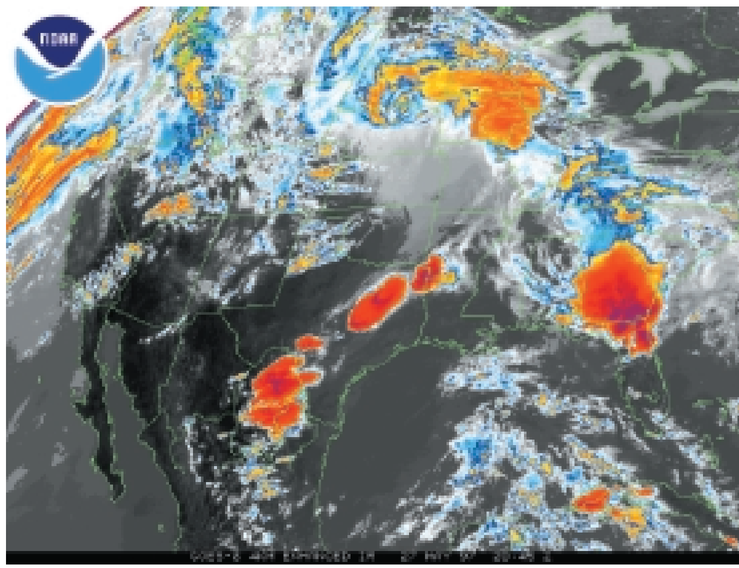
The GOES Image Navigation and Registration (INR) system ensures that Imager and Sounder data is consistent during the day by maintaining the pointing accuracy of the instruments. *Image navigation* is the process of determining the coordinates (Earth latitude and longitude) of each pixel within an image or sounding. *Image registration* is the process of maintaining the coordinates of each pixel within an image or sounding at the same Earth longitude and latitude independent of time.

While in orbit, the spacecraft, and consequently, the instruments, move slightly, which can cause the instruments to look at and scan slightly different areas of the Earth. Other conditions such as vibrations, heat-related distortions, and erroneous signals to the instrument mirrors can also lead to pointing inaccuracies that can produce inconsistent data. The INR system continuously adjusts the aim of the instruments' scan mirrors to compensate for the motion of the spacecraft and other disturbances. The system uses image landmarks, star views, and satellite range data collected throughout the day to make the adjustments.

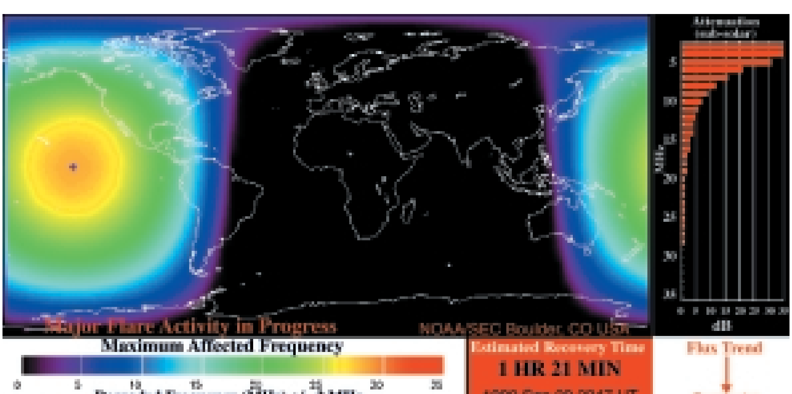
INR Performance Requirements

	Required Pointing Accuracy	Microradians (μrad)	Kilometers (km)
	IMAGER		
0	Imager navigation accuracy	56	2
0	Registration within an image	42	1.5
0	Registration between repeated images		
	15 minutes	28	1
	90 minutes	42	1.5
	24 hours	112	4
0	Channel-to-channel registration	28	1
	SOUNDER		
0	Earth location accuracy	280	10
0	Registration within 120 minute sounding	84	3
0	Registration between repeated soundings		
	90 minutes	84	3
	24 hours	224	8

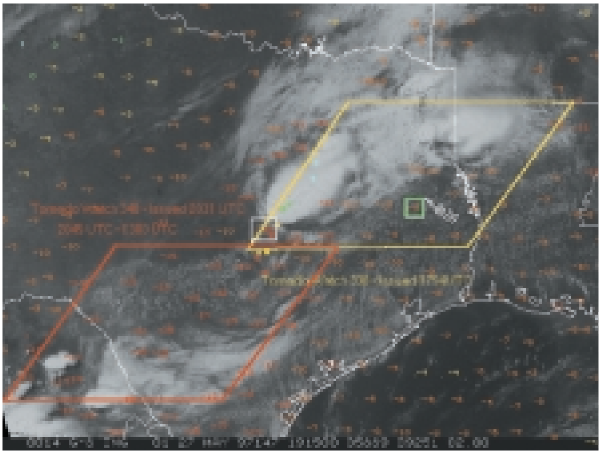
GOES instruments generate many data products and provide several services to the science community, meteorologists, and the public. These include the commonly seen images produced by the Imager and Sounder; data from the SEM that is transmitted to and processed by the SEC in Boulder, Colorado; information gathered by data collection platforms; text, images, and graphics transmitted by EMWIN; data transmitted through the WEFAX/LRIT system; and search and rescue services. A sample of images generated by the Imager, Sounder, and from SEM data appears below and on the pages that follow. For additional data products and images, see the *GOES Products and Services Catalog* published by the National Environmental Satellite, Data, and Information Service (NESDIS) at http://orbit-net.nesdis.gov/arad/fpdt/goescat and at http://osdacces.nesdis.noaa.gov:8081/satprod/.



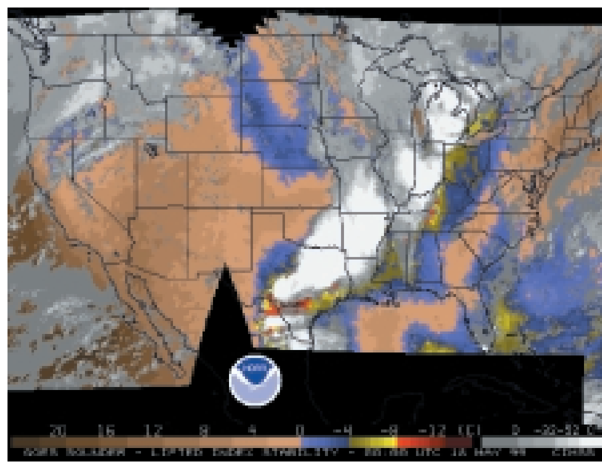
This image shows the Jarrell, Texas tornado event on May 27, 1997. The red areas are clouds with severe storm activity. The image does not distinguish between tornado activity and other severe storms. Radar and other ground information are needed to provide that additional information.



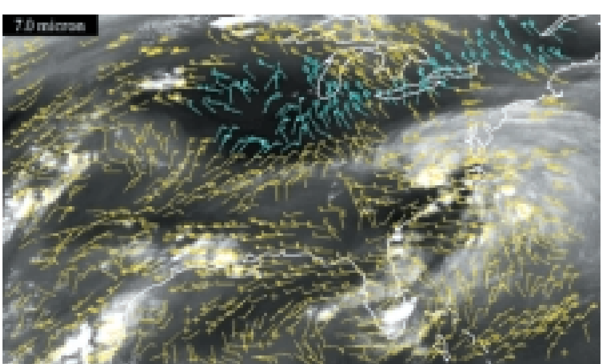
Absorption of high-frequency radio waves in the D-Region of the ionosphere (the lowest layer of the ionosphere) is directly affected by the level of solar x-ray flux. The D-Region absorption product was developed to assist high-frequency radio operators and is based entirely on real-time data from the XRS.



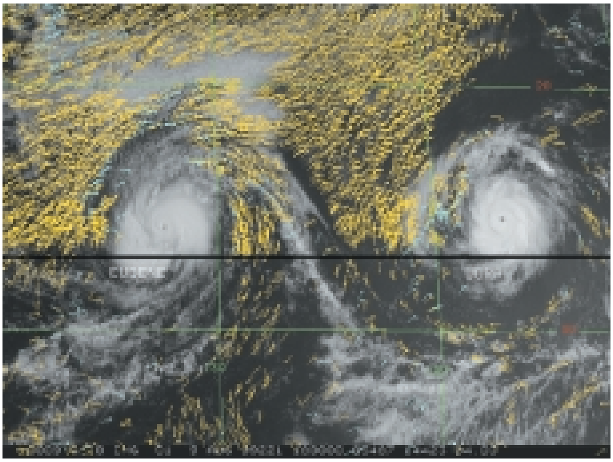
This Sounder-derived image shows the tornado event that occurred near Jarrell, Texas, on May 27, 1997. The numbers, called a lifted index, represent atmospheric stability. The more negative numbers indicate a more unstable atmosphere. A -10 or lower is considered very unstable—a breeding ground for tornados and other severe storms. On this map, the most unstable area is bordered in red, where lifted index numbers fall as low as -16 and where the tornado later broke out.



This image, also derived from Sounder data, shows the degree of stability in the atmosphere as expressed in a lifted index scale that is color-coded at the bottom of the image. The red areas of the map in eastern Texas correspond to quite negative lifted index values. They are the most unstable, with serious potential for tornadoes or other severe storm activity. The beige areas of the map show positive lifted index values. They indicate stable conditions over the southwestern states.

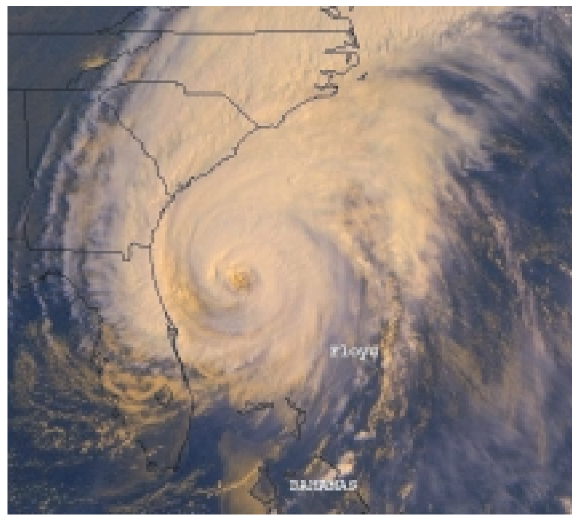


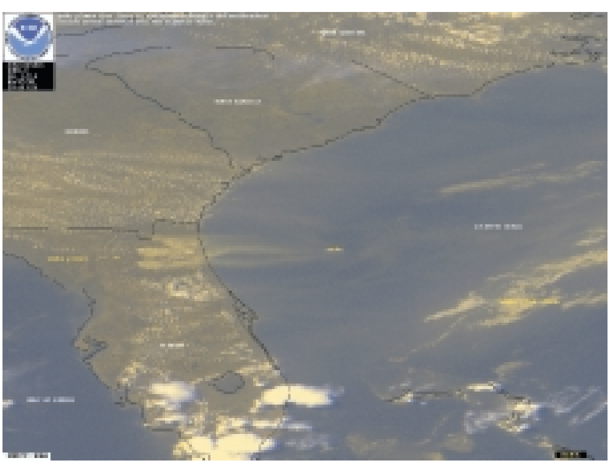
Wind data is derived from the GOES Sounder's water vapor channels in the mid-troposphere, the level of the atmosphere where the jet stream develops and carries weather systems. The straight end of a wind barb points in the direction that the wind is blowing. The density of a barb's tail shows the intensity of the wind. The color of a barb shows its altitude.



This image shows low-level visible cloud-drift winds around hurricanes Eugene and Dora. Three 15-minute sectors (above the black line) and three 30-minute sectors were used to derive the visible winds from Imager data. Note the significant improvement in detail of the wind field from data that was obtained in 15-minute intervals in the top half of the image. The straight end of each wind barb points in the direction that the wind is blowing.

This image of Hurricane Floyd was taken on September 15, 1999, from a color combination of GOES visible channel 1 and infrared channels 2 and 4. This color combination presents high clouds as white, low clouds as yellow (such as in the eye of the hurricane), and the ocean as dark blue.





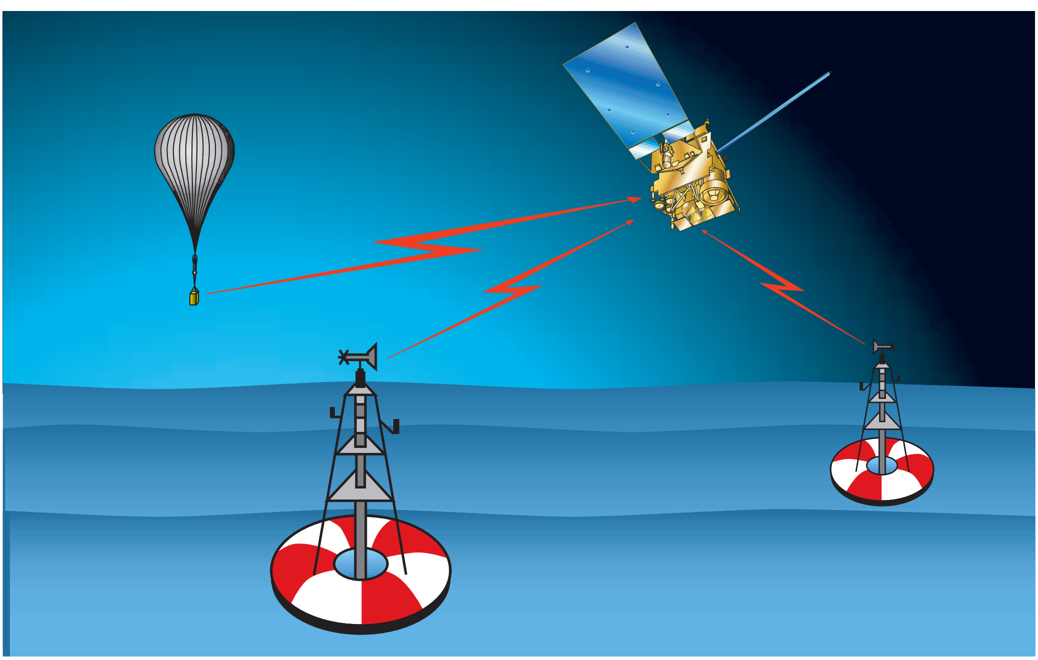
Several fires in northeastern Florida are seen in this image, a color combination of GOES visible channel 1 and infrared channels 2 and 4. Smoke from the fires appears as low (yellow) haze that stretches eastward from northern Florida out over the Atlantic Ocean.

Data Collection System

The Data Collection System (DCS) is a communications relay system that handles information gathered from more than 19,000 data collection platforms located in remote areas. The platforms consist of buoys, free-floating balloons, and remote weather stations. They transmit their data on a 401.9-MHz uplink to the spacecraft. Sensors on the platforms measure environmental factors such as atmospheric temperature and pressure and the velocity and direction of the ocean and wind currents. The DCS transponder on board the spacecraft collects these measurements and provides near real-time relay of environmental data for centralized archiving and distribution. The digital data is used to develop analyses of environmental events such as tsunamis, tropical cyclones, and floods. It is also used to map river stages, soil conditions, and snow depth.

WEFAX/LRIT

The Weather Facsimile (WEFAX) service facilitates the retransmission of images and meteorological analysis from the Wallops CDA ground station to the user community. The data originates from the National Weather Service and from NOAA image-processing facilities. The current analog WEFAX service is being replaced by a digital Low Rate Information Transmission (LRIT). This is an international standard for data transmission that is supported



Data Collection System

by all operational geostationary meteorological satellites flown by the United States, European agencies, Japan, China, and Russia. This system can contain significantly more meteorological data, imagery, charts, and other environmental information than the current WEFAX system.

Emergency Managers Weather Information Network

EMWIN went into service in June 1996. It transmits more than 50,000 pages of text, images, and graphics each day to more than 10,000 users in 35 countries. The service transmits simple, reliable, and affordable data continuously to users by means of an S-band data link.

NASA Support Facilities

The NASA Communications Network (NASCOM) provides voice and communications data circuits during prelaunch, launch, and postlaunch activity. NASA's Kennedy Space Center is responsible for providing support for contractor-provided launch services.

Launch Support

The Deep Space Network (DSN), which is maintained and operated by the Jet Propulsion Laboratory (JPL), supports the launch of GOES spacecraft. DSN tracking stations are located at Merritt Island, Florida; Madrid, Spain; Canberra, Australia; and Goldstone, California. Additional launch support is provided by the NOAA and NASA facilities in Wallops , Virginia.

NOAA Support Facilities

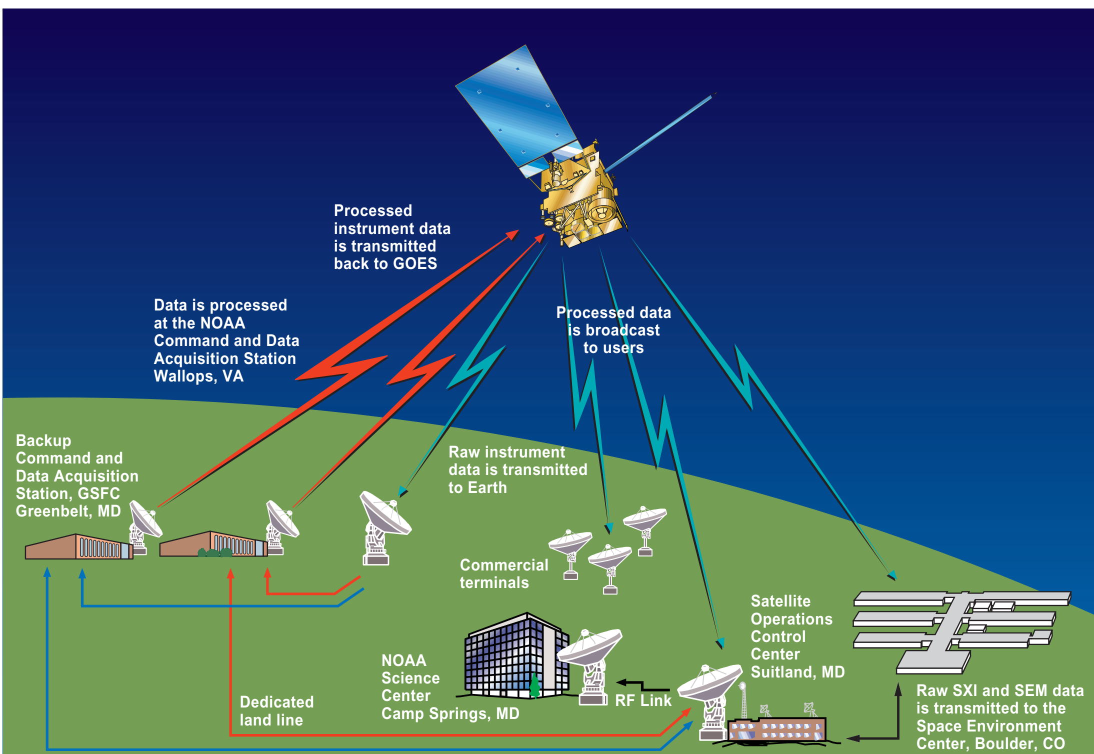
The **Satellite Operations Control Center (SOCC)** is located at Suitland, Maryland. The SOCC is used as the focal point during the GOES launch operations activity. The SOCC is responsible for obtaining necessary satellite data in real time, processing this data for display and analysis, satellite command operations, and mission scheduling. The SOCC also supports the operational phase of the mission after satellite handover to NOAA. NOAA's NESDIS is responsible for configuring, operating, and maintaining the SOCC facility.

The **Space Environment Center** at Boulder, Colorado, receives, processes, and validates data from the SEM and SXI that is used for real-time space weather operations and prepared for archives that are located at the National Geophysical Data Center (NGDC).

The GOES communication system facilitates the transmission of data for the various data products and services described on earlier pages. In addition, it facilitates command and data acquisition activities during the lifetime of each spacecraft.

Command and Data Acquisition

The primary command and data acquisition station (CDAS) is located at Wallops, Virginia. A NOAA backup CDAS is located at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. This backup station, which became operational in September 2000, normally operates in a standby mode. If the primary station at Wallops is threatened or hit by a hurricane, the backup station becomes operational and takes over command and data acquisition functions—ensuring that data from *GOES-East* and *GOES-West* will continue to flow. There are three new 54-ft. (16.4-m) antennas, two at Wallops and one at GSFC, which are designed to operate through a Category 3 hurricane (130 miles per hour) (209 km/hr) and can survive a Category 5 hurricane (155+ miles per hour) (249+ km/hr).



GOES Communications System

The CDAS carries out the command and data acquisition and the processed data relay functions for the GOES program. It transmits commands to the operational satellites and acquires and records instrument and engineering data received from the satellites. Raw instrument data is processed at the CDAS. The processed data is then transmitted to the satellites for rebroadcast to users.

16.4-Meter Backup Antenna at Goddard Space Flight Center

NOAA and NASA are actively engaged in a cooperative program to continue the GOES system with the launch of the GOES NO/P/Q satellites. Since 1974, the two partners have worked jointly to perfect, develop, and complete the GOES program. The current GOES spacecraft are a key element in NOAA's National Weather Service modernization program.

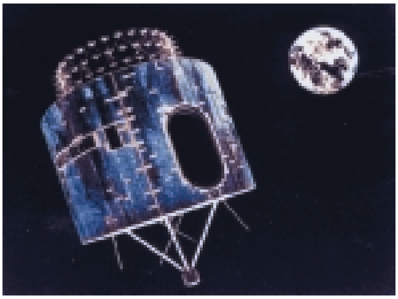
NASA's GSFC procures, develops, and tests the spacecraft, instruments, and unique ground equipment. Following deployment of the spacecraft from the launch vehicle, GSFC is responsible for the mission operations phase leading to the injection of the satellite into geostationary orbit and initial on-orbit satellite checkout and evaluation.

NOAA is responsible for program funding and the on-orbit operation of the system. NOAA also determines the need for satellite replacement. NESDIS is the arm of NOAA that operates the GOES system. It is responsible for implementing, operating, and maintaining the SOCC facility at Suitland, Maryland.

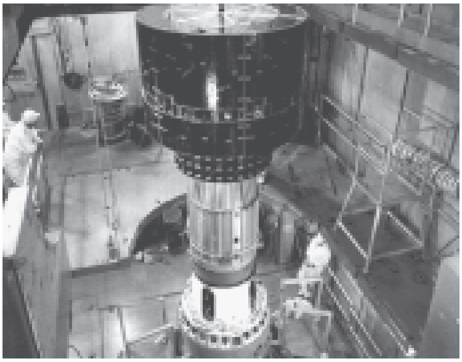
NOAA is also responsible for processing, analyzing, disseminating, and archiving all operational data, which is available to government researchers and others for research and environmental applications. NOAA's Central Data and Distribution Facility (CDDF) at the World Weather Building in Camp Springs, Maryland, and the SEC, along with the NGDC, in Boulder, Colorado, disseminate the data.

NOAA and NASA jointly design, develop, install, and integrate the ground system needed to acquire, process, and disseminate the data from the satellite sensors.

SMS-1 was launched May 17, 1974, from the Eastern Test Range (ETR) at Cape Canaveral, Florida. It was the first geostationary meteorological satellite. Launched from a Delta 2914 space launch vehicle, its objectives were to evaluate a prototype operational meteorological satellite for NOAA's National Weather Service and provide regular daytime and nighttime meteorological observations in support of the national operational meteorological satellite system. The principle instrument on board, the Visible and Infrared Spin Scan Radiometer (VISSR), provided day and night imagery of cloud conditions. The satellite was also equipped with a SEM and a DCS. The satellite also had the capability to perform facsimile transmissions of processed images and weather maps to WEFAX field stations. The satellite was positioned in a geostationary orbit directly over the equator at 45° W (over the central Atlantic), which provided continuous coverage of the central and eastern United States and the Atlantic Ocean. It was operational until January 1976 and was deactivated and boosted out of orbit on January 21, 1981.



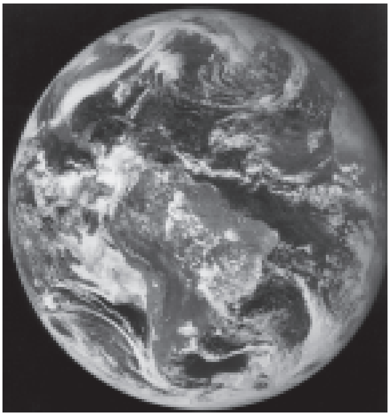
Composite photo showing the on-station position of SMS-1 in 1974



SMS-B erected atop its Delta booster, 1975

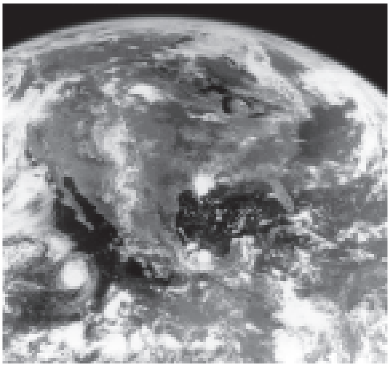
SMS-2 was launched February 6, 1975, from a Delta 2914 space launch vehicle. It was equipped with a VISRR, SEM, and DCS and had WEFAX capability. It was placed in a geostationary orbit directly over the equator at 135° W (over the east-central Pacific). The satellite was moved to an alternate location on December 1975 and was deactivated on August 5, 1982. SMS-1 and SMS-2 proved the viability of geosynchronous meteorological satellites.

GOES-1 (SMS-C/GOES-A) was the first in the series of Geostationary Operational Environmental Satellites. It was launched from a Delta 2914 launch vehicle on October 16, 1975. Its instrument complement was identical to SMS-1 and SMS-2. GOES-1 was placed over the Indian Ocean west of SMS-2 so that the combined coverage of the three satellites would include nearly 60 percent of the Earth's surface. It operated successfully in this orbit until GOES 3 was launched in June 1978 when GOES-1 was relocated to replace SMS-2. It was deactivated on March 7, 1985.



GOES-1 image, October 25, 1975

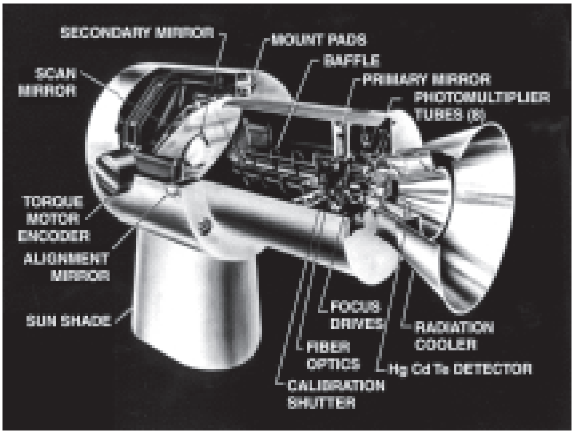
GOES-2 (GOES-B) was launched on June 16, 1977 from a Delta 2914 launch vehicle. Its instrument complement was identical to the SMS and GOES-1 satellites. GOES-2 was placed in orbit directly over the equator at 60° W to replace SMS-1. It was operational until 1993. It was reactivated in 1995 to broadcast National Science Foundation (NSF) transmissions from the South Pole to public broadcasting facilities in the United States. The WEFAX system on GOES-2 continued to operate, although cloud images were no longer being received from the system, until the satellite was deorbited at the beginning of May 2001.



GOES 3 image, October 23, 1978

GOES 3 (GOES-C) was launched June 16, 1978, from a Delta 2914 launch vehicle. The satellite was designed to replace GOES-1 over the Indian Ocean as part of the Global Atmospheric Research Program (GARP). It had the same instruments and capabilities as the earlier GOES spacecraft. GOES 3 is currently being used by the University of Miami for communications purposes.

GOES 4 (GOES-D) was launched September 9, 1980 from a Delta 3914 space launch vehicle. It was the first geostationary satellite to provide continuous vertical profiles of atmospheric temperature and moisture. The primary instrument on GOES 4, the VISSR Atmospheric Sounder (VAS), provided both day and nighttime imagery of cloud conditions as well as temperature and moisture profiles. Instrument limitations did not permit both types of operations simultaneously. The satellite also used new despun S-band and UHF antennas to improve the relay of meteorological data from more than 10,000 surface locations into a central processing center for incorporation into numerical weather prediction models and to transmit processed images and weather maps to WEFAX field stations. It was also equipped with a SEM and DCS similar to those on previous GOES. GOES 4 was placed in orbit at 135° W to replace the failing GOES 3. Its most serious anomaly occurred on November 25, 1982, when the VAS's scan mirror stopped during retrace after exhibiting excessively high torque. Efforts to restore either the visible or infrared capability were unsuccessful. It was deactivated on November 22, 1988.



VAS was found on GOES 4 through GOES 7

GOES 5 (GOES-E) was launched May 22, 1981, from a Delta 3914 launch vehicle. Its instrument complement was identical to GOES 4. It was placed in orbit at 75° W longitude. The satellite failed on July 29, 1984, when an encoder lamp filament burned out that was needed to read the angle of the scan mirror used to obtain images. It was deactivated on July 18, 1990.

GOES 6 (GOES-F) was launched April 28, 1983, from a Delta 3914 launch vehicle. It was designed to replace GOES 4 and was originally placed in orbit at 136° W. After GOES 5 failed, it was moved to a central location at 98° W. When GOES 7 was placed in service, it was returned to its original location. The VAS imager on GOES 6 failed on January 21, 1989, so direct readout images and soundings were no longer available. WEFAX continued to transmit until the spacecraft was deactivated on May 24, 1992.

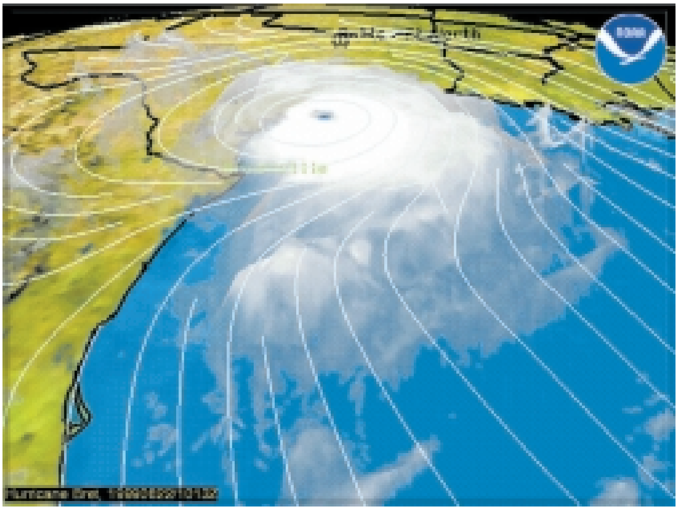
GOES G was launched May 3, 1986. The spacecraft did not reach operational orbit because of a failure in the launch vehicle that was attributed to an electrical shortage which shut down the engines on the Delta.

GOES 7 (GOES-H) was launched February 26, 1987, and was placed in orbit at 75° W. The spacecraft was moved to 98° W in July 1989 following the January 1989 failure of GOES 6. In 1992, GOES 7 ran out of stationkeeping fuel, as expected. Without fuel for orbital maneuvers required to stay located on the equator, its orbital inclination increased by approximately 1 degree each year due to tidal forces. The non-zero inclination made raw animation of the Earth unstable. GOES 7 went to standby in January 1996 and was parked at 95° W in June 1996. Consequently, the VAS instrument and the associated data, along with WEFAX, DCS, and search and rescue services through GOES 7, were deactivated. In mid-November 1999, GOES 7 was moved to 175° W to take over the communications-relay duties of PEACESAT. The high orbital inclination made it possible to relay data from near the poles, particularly to support the NSF science group at the South Pole. In addition to the same instrument complement as the earlier GOES, GOES 7 carried experimental search and rescue equipment that allowed near-instantaneous detection of emergency distress signals on the ground transmitting at 406 MHz.

When satellites are launched, they receive a letter designation. After they reach orbit, they are assigned a number. This prevents a missing number if a spacecraft does not reach orbit successfully.

GOES 8 (GOES-I) was launched April 13, 1994, from an Atlas-I/Centaur launch vehicle. In 2001, it is operational as GOES-East at 75° W. It was the first in a new series of three-axis stabilized GOES that provided significant improvements over the previous GOES system in weather imagery and atmospheric sounding information. The satellite is equipped with a separate Imager and Sounder, which allows simultaneous and independent imaging and sounding. Previously, both functions were performed alternately by a single instrument. GOES 8 features flexible scan that offers small-scale area imaging, resulting in improved short-term forecasts over local areas. It is also equipped with a SEM, DCS, has WEFAX capabilities, and performs near-instantaneous relay functions for the SARSAT system with its dedicated search and rescue transponder.

GOES 9 (GOES-J) was launched May 23, 1995, from an Atlas-I/Centaur launch vehicle into a geostationary orbit at 135° W. It was deactivated on July 28, 1998 due to failing bearings in the momentum wheels and is in storage.



Hurricane Bret, 1999

GOES 10 (GOES-K) was launched April 25, 1997 from an Atlas I/Centaur launch vehicle and was placed in orbit at 105° W. It has the same instrument complement as GOES 8 and GOES 9. In the spring of 1998, GOES 10 was shut down and designated an "on-orbit spare" until the failure of GOES 8 or GOES 9. Shortly thereafter, GOES 9 began experiencing problems with its momentum wheels, and GOES 10 was placed in active service as GOES-West, positioned at 135° W. GOES 10 ceased rotating to follow the sun but due to the ingenuity of the U.S. satellite developers, it is working well as it orbits upside down and the solar array rotates in reverse.

GOES 11 (GOES-L) was launched May 3, 2000 and placed in storage mode at 105° W in August 2000. It has the same instrument complement as GOES 8, 9, and 10.

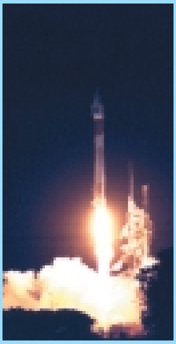
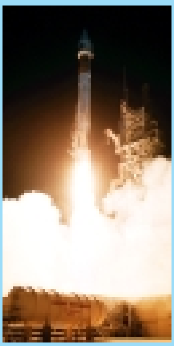
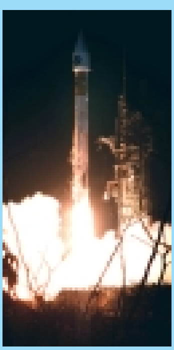
GOES-M (to become GOES 12) is scheduled to be launched in July 2001. It will be the first GOES to fly an SXI-type instrument.

The SMS and GOES 1-3 spacecraft were built by Ford Aerospace and Communications Corporation. The GOES 4-7 series was built by Hughes Space and Communications. The GOES 8-12 series was built by Space Systems/Loral.

As well as the web sites mentioned elsewhere in this brochure, see http://www.oso.noaa. gov/goes/index.htm, http://goes2.gsfc.nasa.gov, and http://rsd.gsfc.nasa.gov/goes for additional information on the GOES program and GOES science. For additional copies of this brochure, please write to: GOES Program Manager, NASA Goddard Space Flight Center, Mail Code 415, Greenbelt, MD 20771.

Acronyms

mrad	microradian
AFB	Air Force Base
AFRCC	Air Force Rescue Coordination Center
AKRCC	Alaskan Rescue Coordination Center
BSS	Boeing Satellite Systems, Inc. (formerly Hughes Space and Communications Company
bps	bits per second
CCD	Charge Coupled Device
CDAS	Command and data acquisition station
CDDF	Central Data and Distribution Facility
CEB	Camera Electronics Box
COSPAS	*Cosmicheskaya Sistyema Poiska Avariynich Sudov* (Space System for the Search of Vessels in Distress)
DCP	Data Collection Platform
DPU	Data Processing Unit
DCS	Data Collection System
DSN	Deep Space Network
ELT	Emergency Locator Transmitter
EMWIN	Emergency Managers Weather Information Network
EPEAD	Energetic Proton, Electron, and Alpha Detector
EPIRB	Emergency Position-Indicating Radio Beacon
EPS	Energetic Particle Sensor
ER	Eastern Range
ETR	Eastern Test Range
EUV	Extreme Ultraviolet
FOV	Field of view
GARP	Global Atmospheric Research Program
GEM	Graphite epoxy motor
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
HASS	High Accuracy Sun Sensor
HEPAD	High Energy Proton and Alpha Detector
Hz	Hertz
INR	Image navigation and registration
IR	Infrared
ITT A/CD	ITT Aerospace/Communications Division
JPL	Jet Propulsion Laboratory
K	Kelvin temperature in degrees
kg	kilogram
kHz	kilohertz
km	kilometer
kW	kilowatt
LAM	Liquid apogee motor
lb	Pound
LH_2	Liquid hydrogen
LMATC	Lockheed Martin Advanced Technology Center
LO_2	Liquid oxygen
LRIT	Low Rate Information Transmission
LUT	Local User Terminal
m	meter
MAGED	Magnetosphere Electron Detector
MAGEP	Megnetosphere Proton Detector
MCC	Mission Control Center
MECO	Main engine cutoff
MHz	Megahertz
N	Newton
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications
NGDC	National Geophysical Data Center
NiH_2	Nickel hydrogen
nm	nanometer (one-billionth of a meter)
NSF	National Science Foundation
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
PLB	Personal Locator Beacon
PSK	Phase shift keyed
PSS	Precision Sun Sensor
RCC	Rescue Coordination Center
RF	Radio frequency
SAIC	Science Applications International Corporation
SARSAT	Search and Rescue Satellite-Aided Tracking
SEC	Space Environment Center
SECO	Second engine cutoff
SEM	Space Environment Monitor
SLV	Space launch vehicle
SMS	Synchronous Meteorological Satellite
SOCC	Satellite Operations Control Center
SXI	Solar X-Ray Imager
UHF	Ultra high frequency
USMCC	U.S. Mission Control Center
VAS	VISSR Atmospheric Sounder
VISSR	Visible Infrared Spin Scan Radiometer
WEFAX	Weather Facsimile
XRS	X-Ray Sensor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